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January 1986

HAZARDOUS WASTE MANAGEMENT PRACTICES

IN THE UNITED STATES

by

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Alternative Technologies Division
Hazardous Waste Engineering Research Laboratory
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Cincinnati, Ohio 45268

HAZARDOUS WASTE ENGINEERING RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OH 45268

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This paper was prepared for presentation at a joint US/Spain Seminar on Hazardous Waste Management to be held in Madrid, Spain, on May 19-22, 1986.

Hazardous waste quantities produced in the United States and how they are handled/disposed of are presented. Major environmental legislation is discussed. Organization and description of research activities of the Hazardous Waste Engineering Research Laboratory are provided.

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FOREWORD

Today's rapidly developing and changing technologies and industrial products and practices frequently carry with them the increased generation of solid and hazardous wastes. These materials, if improperly dealt with, can threaten both public health and the environment. Abandoned waste sites and accidental releases of toxic and hazardous substances to the environment also have important environmental and public health implications. The Hazardous Waste Engineering Research Laboratory assists in providing an authoritative and defensible engineering basis for assessing and solving these problems. Its products support the policies, programs and regulations of the Environmental Protection Agency, the permitting and other responsibilities of State and local governments and the needs of both large and small businesses in handling their wastes responsibly and economically.

Hazardous waste quantities produced in the United States and how they are handled/disposed of are presented. Major environmental legislation is discussed. Organization and description of research activities of the Hazardous Waste Engineering Research Laboratory are provided.

For further information, please contact the Alternative Technologies Division of the Hazardous Waste Engineering Research Laboratory.

David G. Stephan, Director
Hazardous Waste Engineering Research Laboratory

ABSTRACT

Hazardous waste may be stored, treated and disposed in a variety of ways. Treatment technology exists today for detoxification or destruction of wastes in an environmentally acceptable manner through physical, chemical and biological means. This paper describes the sources of hazardous wastes in the United States and how they are handled/disposed. Major environmental legislation is outlined. Organization and description of the research activities of the Hazardous Waste Engineering Research Laboratory are provided.

CONTENTS

Foreword iii

Abstract iv

Figures vi

Introduction 1

The Nature and Scope of the Problem 1

Storage 9

Transportation 10

Treatment/Disposal 10

U. S. Environmental Legislation 10

The Solid Waste Disposal Act as Amended by the Resource Recovery Act 11

The Resource Conservation and Recovery Act 12

State Hazardous Waste Programs Under RCRA 15

The Comprehensive Environmental Response, Compensation, and Liability Act 15

New EPA Approaches to Hazardous Waste Management Research 17

Hazardous Waste Engineering Research Laboratory, Cincinnati, Ohio, U.S.A. 17

References 21

Appendix A, Technical Assistance Reference Directory, Land Pollution Control Division 22

Appendix B, Technical Assistance Reference Directory, Alternative Technologies Division 25

FIGURES

		Page
Figure 1.	Map of the United States	2
Figure 2.	Distribution of Hazardous Waste Management Facilities in 1981 by EPA Region	3
Figure 3.	Number of Facilities with Treatment, Storage, and/or Disposal in 1981	4
Figure 4.	Number of Facilities Treating Hazardous Waste in 1981, by Treatment Process Type	5
Figure 5.	Number of Facilities Storing Hazardous Waste in 1981, by Storage Process Type	6
Figure 6.	Number of Facilities Disposing of Hazardous Waste in 1981, by Disposal Process Type	7
Figure 7.	Disposition of Hazardous Waste Generated: Quantity Managed On-Site Versus Shipped Off-Site for Management	8
Figure 8.	Organization Chart of the Hazardous Waste Engineering Research Laboratory	18

HAZARDOUS WASTE PRACTICES IN THE UNITED STATES

U.S. ENVIRONMENTAL PROTECTION AGENCY

Introduction

In the papers of this joint seminar, specific information important in the field of hazardous waste management will be presented. This information, along with the exchange of information during the seminar between the Spaniards and the Americans will facilitate learning from each other. Important areas of concern will be identified and alternative ways to approach these specific problems will be discussed.

To help assure a continuing dialogue, in addition to the usual seminar proceedings, a technical assistance reference directory has been included as an addendum to this paper. This directory lists the areas of technology being worked on by the Hazardous Waste Engineering Research Laboratory and the specific researchers who specialize in each area.

This paper presents an outline of the growth of interest in hazardous waste environmental problems in the United States and the history of how the United States has moved toward solutions.

The Nature and Scope of the Problem

Virtually every commercial activity generates waste. The passage of environmental legislation has put businesses in the position of scrutinizing the commercial processes that generate these materials in order to reduce the volume of waste produced. Wastes that are deemed hazardous generally result from the following activities:

1. Manufacturing processes that produce an unwanted or unusable by-product,
2. Finished products that are unusable for a variety of reasons,
3. Spills of virgin materials, and

4. Unused products or residuals remaining after product use.

The types of wastes included under our laws as hazardous will be presented in a separate paper.

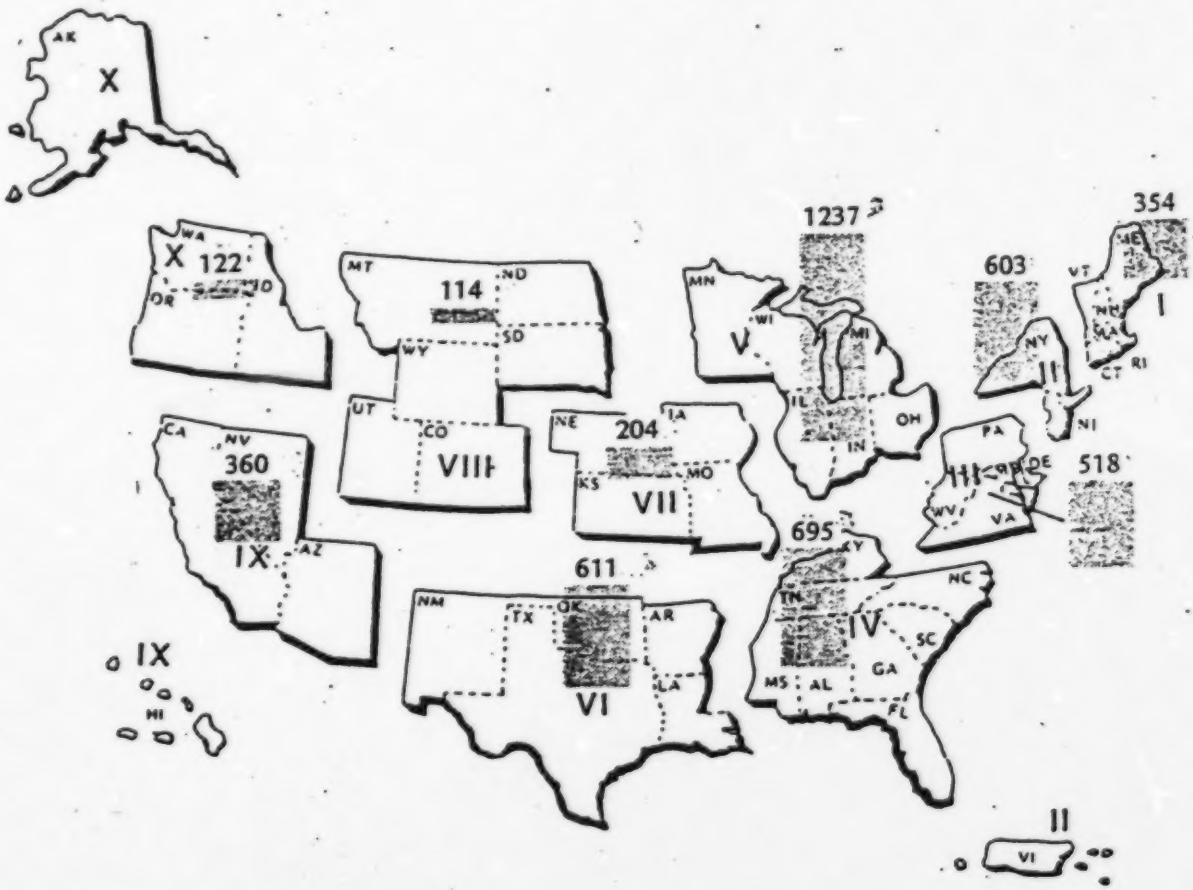
The complexities of the hazardous waste problems in our country are shown by a map of the United States (Figure 1) which indicates the distribution of hazardous waste generation by state. Note that 75% of the annual total of 56,770,000 metric tons is generated in about one third of the total area. An important change in recent amendments to the Resource Conservation and Recovery Act (RCRA) lowered from 1000kg/month to 100 kg/month the quantities of wastes subject to the law. This did not drastically increase the quantity of waste under regulation but increased by thousands the number of generators subject to the law.

Figure 1

This distribution of waste generation is reflected by the fact that 71% of the hazardous waste management facilities are located in the eastern most portion of the 48 contiguous states. Of a total of 4818 management facilities, 3407 are located east of the Mississippi River.

DISTRIBUTION OF HAZARDOUS WASTE MANAGEMENT FACILITIES IN 1981

BY EPA REGION

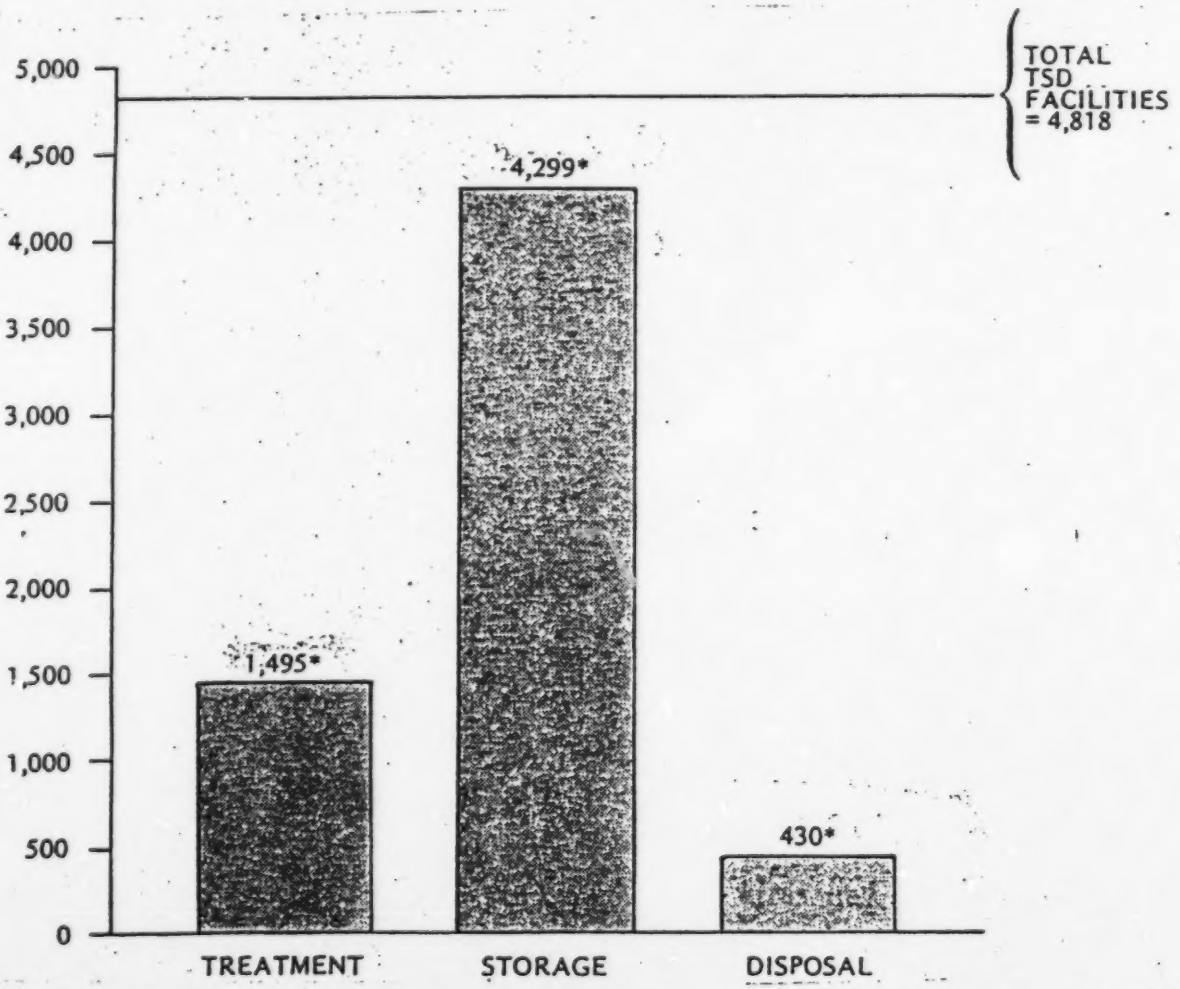


The estimated total number of active treatment, storage and disposal facilities in 1981 was 4,818.

Figure 2

Hazardous waste facilities in the United States are divided into three groups: treatment, storage, and disposal. Of the 4818 facilities, there are a number that participate in more than one type of handling, but the general percentages, by type, are 31% for treatment plants, 89% for storage sites, and 9% for disposal sites.

NUMBER OF FACILITIES WITH TREATMENT, STORAGE, AND/OR DISPOSAL IN 1981

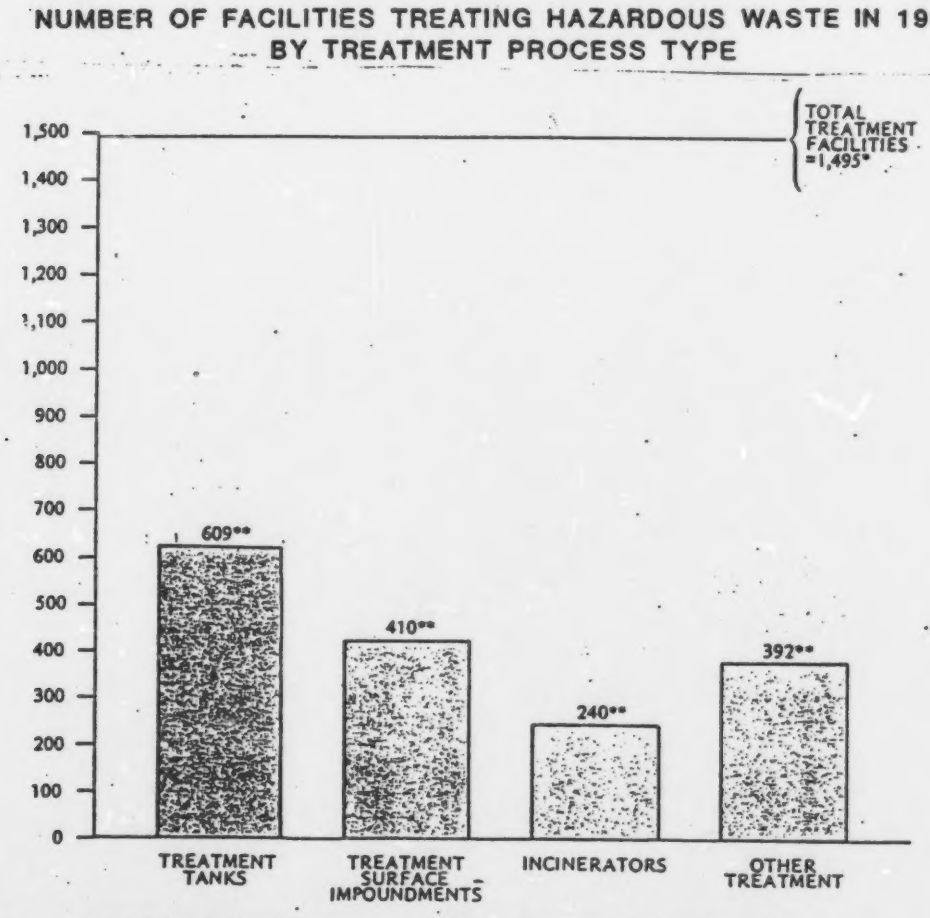


*Treatment + Storage + Disposal exceeds 4,818 due to multiple processing at facilities. Some treatment facilities shown here may be RCRA-exempt (see footnote on previous page).

Figure 3

In the United States, interest in detoxifying or destroying hazardous wastes has increased significantly within the last year. Recent amendments to RCRA call for banning most hazardous wastes from land disposal within five years. The nature of treatment plants in 1981 was:

- 41% treatment tanks,
- 27% treatment surface impounds,
- 17% incinerators, and
- 26% other types of treatment.



*Some of these treatment facilities may be RCRA-exempt (see Section 5.4 footnote)

**Tanks + Impoundments + Incinerators + Other exceeds 1,495 because some facilities had more than one treatment type.

Figure 4

Up to now most management of hazardous waste was by some form of storage.

There are 4299 management facilities that store hazardous waste and of these:

- 74% employ containers,
- 33% employ storage tanks,
- 13% employ storage surface impounds,
- 4% employ waste piles, and
- 3% employ other types of storage.

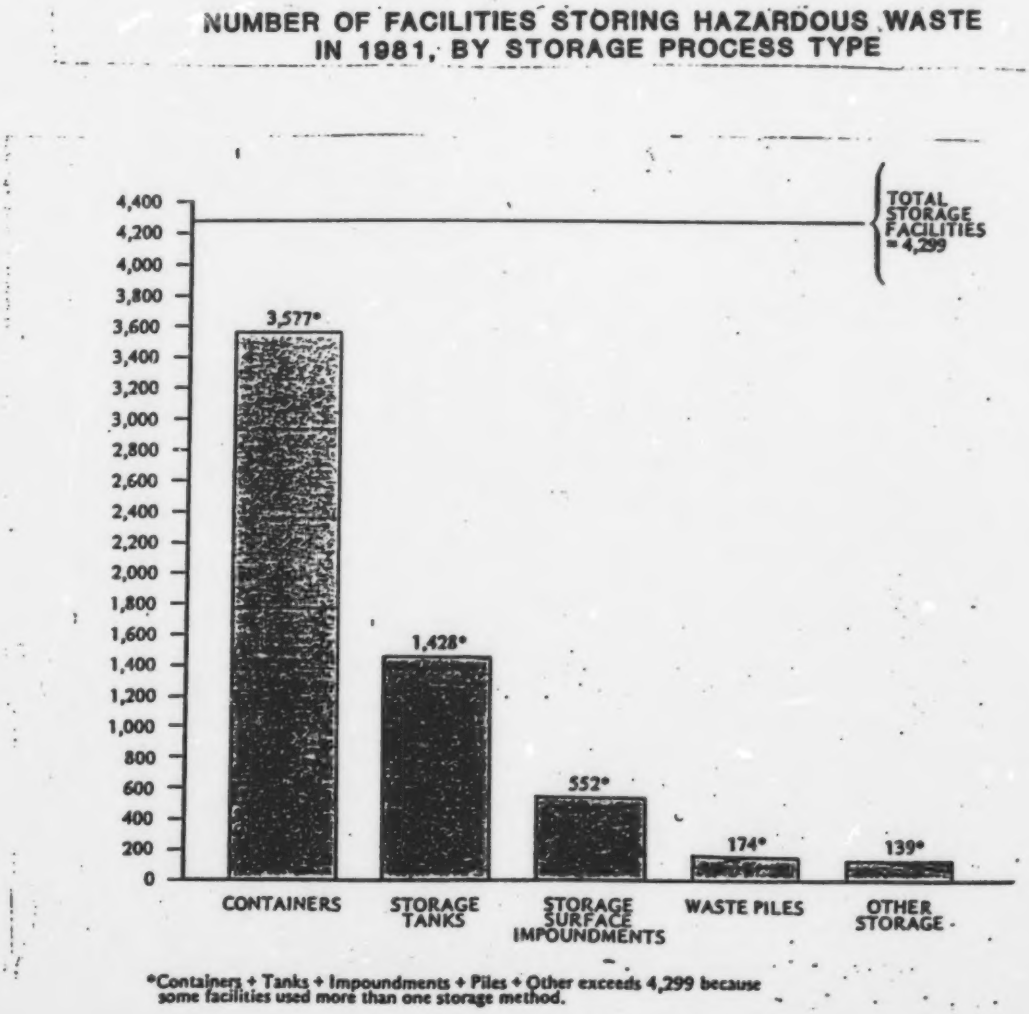
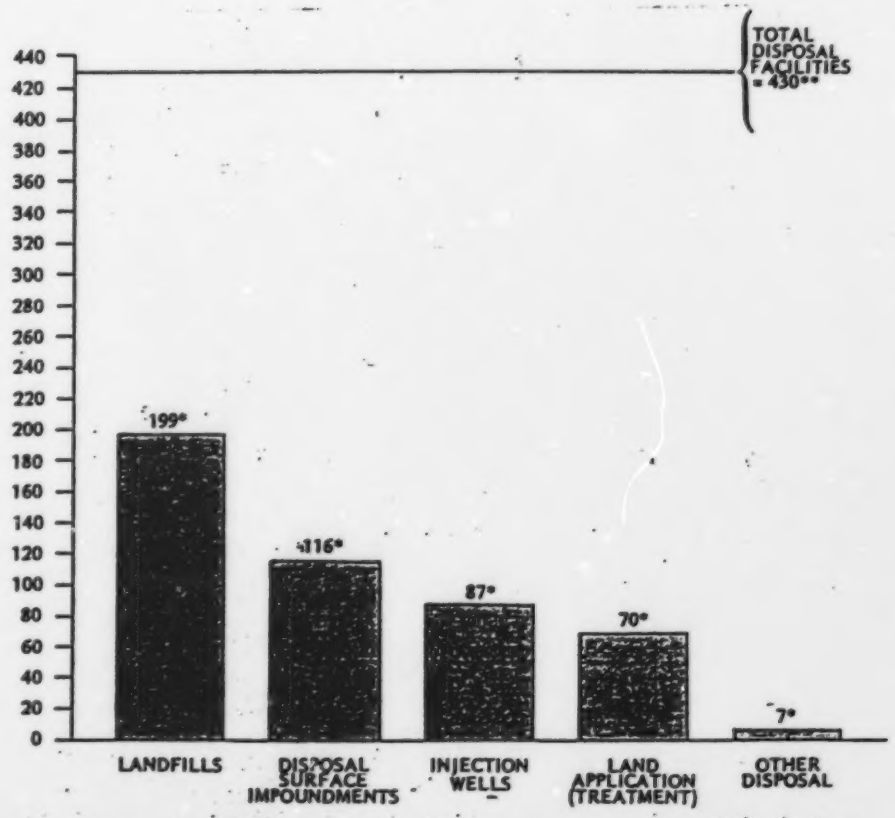


Figure 5

Disposal methods shown below represented 430 hazardous waste facilities in 1981:

- 46% landfills,
- 27% disposal surface impoundments,
- 20% injection wells,
- 6% landfill application treatment, and
- 2% other types of disposal.

NUMBER OF FACILITIES DISPOSING OF HAZARDOUS WASTE IN 1981, BY DISPOSAL PROCESS TYPE



*Landfills + Impoundments + Wells + Land Application + Other exceeds 430 because some facilities used more than one disposal method.

**Does not include waste piles or surface impoundments used for treatment or storage of hazardous waste.

Figure 6

In the United States most wastes are handled on-site as shown by Figure 7. Only 4 percent are shipped to another site, and less than 1 percent is transported to another firm . This eliminates much of the possible hazard associated with moving waste over our public transportation system.

DISPOSITION OF HAZARDOUS WASTE GENERATED:

QUANTITY MANAGED ON-SITE VERSUS SHIPPED OFF-SITE FOR MANAGEMENT

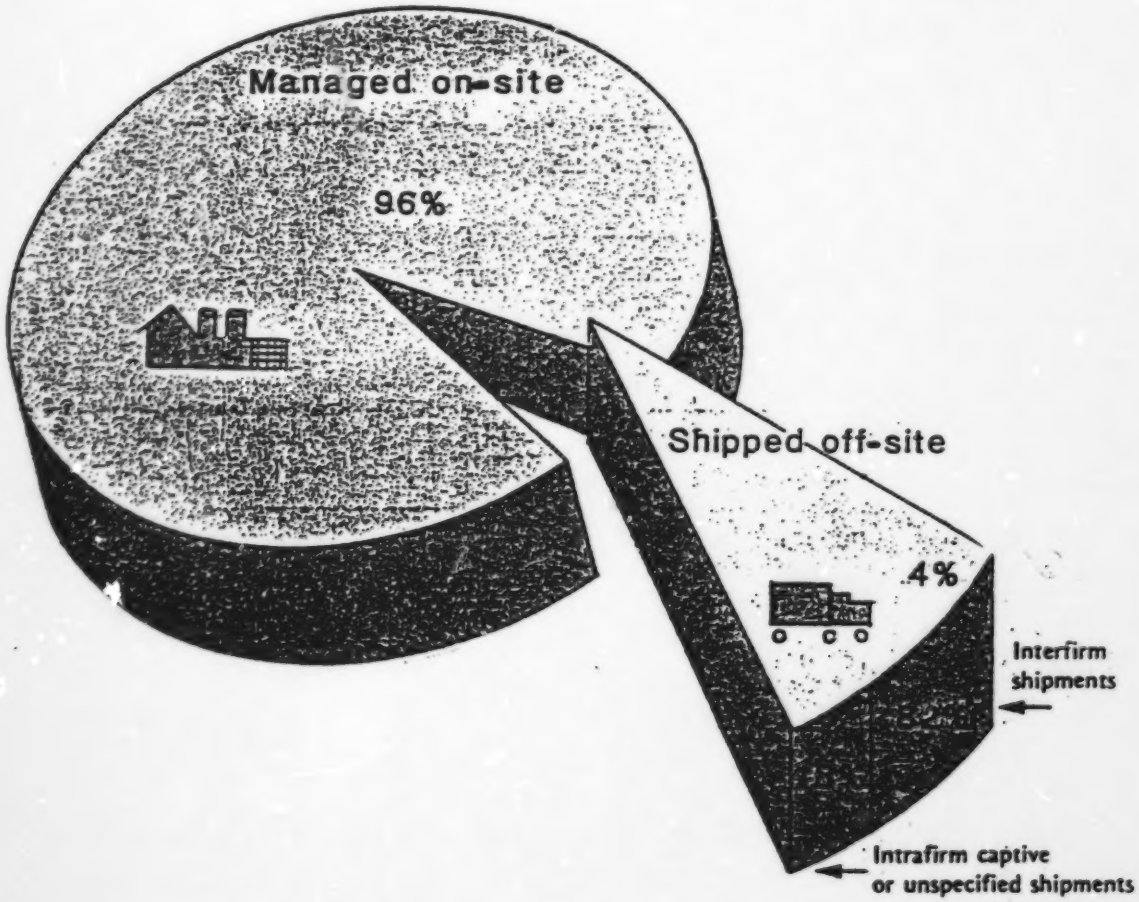


Figure 7

Storage

Both governmental agencies and non-governmental institutions are expressing increased concern about the storage of hazardous materials. Under the new laws, EPA specifies design and operation standards and permit requirements for generators storing hazardous wastes more than 90 days and for non-generators operating hazardous waste storage facilities.

Citizen concern about the environmental damage potential of improperly operated storage, treatment, and disposal facilities can cause embarrassment to and legal action against companies. As a result of this concern, strict local codes and/or local opposition to sites of hazardous waste treatment facilities are becoming more common.

Insurance carriers are also especially aware of their potential losses from environmental damage and the new demands indirectly placed on them by recent legislation. Obtaining liability insurance to protect against accidents or further environmental impacts from hazardous waste is becoming increasingly more expensive and difficult.

In some cases, simply storing a material too long can "automatically" produce a waste. Materials stored longer than their shelf-life expiration date may change or develop new hazardous characteristics (such as flammable ether becoming shock-sensitive or explosive prone as peroxidation inhibitors deteriorate and peroxides form). The material then becomes not only a hazardous waste but also a special disposal problem that can be dangerous to dispose of or handle.

Poorly managed storage areas may also result in fines and penalties for storing too much waste (like a small quantity generator exceeding his exemption limits) or for storing waste too long (as a generator exceeding his 90 day storage limit).

Storage of waste materials should incorporate all of the safety provisions and management techniques and procedures used in storing virgin chemicals or other products with similar characteristics.

Transportation

With the passage of RCRA, we have developed regulations governing the packaging and transportation of hazardous wastes. Many of these regulations are the work of our Department of Transportation (DOT). These are designed to standardize packaging and labeling of wastes and insure proper handling as they are being transported. A scheme of "Reportable Quantities" has been put in place that exempts from regulation limited, small quantities of waste depending upon the degree of hazard of the material.

Treatment/Disposal

Later in this seminar my colleagues will define the alternative ways wastes are handled in the United States. They will also describe some of the more promising technologies that are emerging and indicate how we believe they will be used. Many of the technologies presented are also applicable to problems associated with abandoned sites or contaminated soils and sediments.

U. S. Environmental Legislation

A number of major Acts have been established to protect the environment in the United States. The most important of these are:

1. Clean Air Act (1963, amended 1970 and 1977);
2. Solid Waste Disposal Act (1965) as amended by The Resource Recovery Act (1970);
3. Safe Drinking Water Act (1974);
4. Resource Conservation and Recovery Act (1976, amended 1984);

5. Clean Water Act (1977); and
6. Comprehensive Environmental Response, Compensation, and Liability Act (1980).

Each of these Acts provides for research, development, and demonstration of technologies and methods for treating specific pollutants, training of individuals to work in the field of environmental control, standards for controlling discharges, emissions and disposal of waste materials or pollutants, and a legal framework for permitting of facilities and operators. The Resource Conservation and Recovery Act, and the Comprehensive Environmental Response, Compensation, and Liability Act form the legislative background for Hazardous Waste Management in the United States.

The Solid Waste Disposal Act (SWDA) as Amended by the Resource Recovery Act (RRA)

SWDA/RRA authorized a feasibility study discussing "the creation of a system of national disposal sites for the storage and disposal of hazardous wastes, including radioactive, toxic chemical, biological and other wastes which may endanger public health or welfare." The study included analysis of:

1. Waste materials which would be handled at these sites;
2. Current methods of disposal;
3. Recommended methods of volume reduction, neutralization or disposal;
4. Sites which may be suitable for operation by Federal agencies; and
5. Cost analysis of construction and operation including means for the distribution of costs among users.

The subsequent studies were sent to Congress over a period of years in four parts. Included were:

1. Reports on total estimated hazardous waste generation;
2. Suggested and preferred methods of disposal for "off-site" processing at a regional facility or "on-site" pretreatment followed by "off-site" treatment and disposal;

3. Current cases of improper disposal; and

4. Suggestions for future regulation.

No regulations were produced by this Act, but the study revealed to Congress the tremendous demand placed on land disposal (landfills) as other environmentally unacceptable disposal options are eliminated.

The Resource Conservation and Recovery Act (RCRA)

The proper management of hazardous wastes must be dealt with now. Because of the recognition of this, the Congress of the United States enacted the Resource Conservation and Recovery Act (RCRA) of 1976. RCRA restricts what can be done with waste by-products having defined hazardous characteristics. In the United States almost 400,000 generators, transporters and disposal site operators are affected by this law and its subsequent regulations.

RCRA establishes a comprehensive program for Federal and State regulation of solid waste management and disposal. RCRA gives the Federal Government direct authority to regulate the handling and management of hazardous wastes and it encourages the States to require improved management and disposal practices for non-hazardous solid wastes.

Under RCRA, EPA regulations state hazardous waste may only be deposited in Secure Chemical Landfills. Secure Chemical Landfills must meet specific containment, leachate collection, and groundwater monitoring standards.

RCRA amended the earlier law titled the Resource Recovery Act, which placed emphasis on the regulatory aspect of waste disposal, and recognized the national problems of solid and hazardous waste disposal. RCRA authorized:

1. Grants for improving solid waste management;

2. Technical support for research, development and training;

3. Prohibition of open dumping;

4. EPA regulation of hazardous wastes; and

5. Demonstration and construction of resource recovery technologies.

EPA first alerted Congress to evidence of "significant deterioration of human health and environment" by compiling a list of incidents. Some of them described the leaching of toxic materials from municipal landfills, the contamination of underground sources of drinking water, the explosion of drums of reactive wastes, and the spillage of toxic liquids and sludges from damaged lagoons. The effects of generator's and disposer's practices were ". . . unknowable in terms of the state of knowledge and art at the time of the original disposition."

Prior to the enactment of RCRA, the management of hazardous waste was integrated closely with the solid waste disposal industry. This Act defined, for the first time, "hazardous wastes" by separating them from solid waste management. The need for this division of terms became apparent as disposal practices and technologies formerly ". . . considered acceptable" by industry, government agencies, hospitals, research laboratories and other waste generators, proved less than adequate.

Fortunately, in reviewing the past several years, we find that generators are assuming an increased role of responsibility for hazardous waste disposal, and the waste disposal industry is developing and implementing more environmentally-acceptable technologies.

One important aspect of recent amendments to RCRA is the planned prohibition of hazardous waste from land disposal over a five-year period. This Act also establishes a "cradle to grave" hazardous waste management program to protect public health and the environment from improper disposal of hazardous waste. EPA is charged with the responsibility for developing specific regulations or standards for the general RCRA requirements. The law is organized into specific sections as follows:

1. Hazardous Waste Management System; General;
2. Identification and Listing of Hazardous Waste;
3. Proposal to Modify 40 CFR Part 261--Hazardous Waste Lists;
4. Standards Applicable to Generators of Hazardous Waste;
5. Standards Applicable to Transporters of Hazardous Waste;
6. Standards and Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities;
7. Proposal to Modify 40 CFR Part 265--Subpart H--Financial Requirements; and
8. Proposal to Modify 40 CFR Part 265--Subpart R--Underground Injection.

The policy of the United States Environmental Protection Agency, established in accordance with this Act, sets an order of priority for consideration of the methods for handling or disposing of hazardous waste. The first option to be considered is the reduction or elimination of the waste. If this is not practical or possible, the next option is to recycle or reuse the waste material, and if neither of these options is practical or obtainable, the third is to treat the waste so as to render it non-hazardous or to reduce the hazard to the point at which disposal can be carried out without danger to health or the environment. In this hierarchy, land disposal is considered as a last resort except for wastes that have been treated to meet the criteria for this type of disposal.

In implementing this hierarchy ranking, there is very wide variation in the availability of technology to accomplish these goals. A significant amount of experience of waste elimination, waste reduction, and recycle and reuse of hazardous wastes exists in the pulp and paper industry, the electroplating and metal finishing industry and in others, such as the photographic and tanning industries. These are not as widespread as one

might like nor are there waste reduction or recycle/reuse techniques available for even a significant number of the hazardous waste problems but there is at least a body of proven techniques for which data, costs, etc., are available. The treatment of hazardous waste by other than thermal means, that is incineration, is not particularly advanced. Prior to the regulatory and economic pressure being generated by laws controlling hazardous waste, little if any attention was given to the treatment of these wastes. In the United States, before RCRA, these wastes are the ones which were shown on flow sheets with an error captioned "to landfill." This seminar will provide the latest information we have available on hazardous waste treatment techniques.

State Hazardous Waste Programs Under RCRA

It is expected that a majority of the 50 States, (which are structured similarly to Spain's 51 Provinces) will apply to EPA for authorization to enforce the provisions of RCRA. For those States that either do not apply or are not qualified, EPA will retain enforcement authority based on the Federal standards.

EPA has established minimum requirements which a state must meet in order to be fully authorized by EPA. The State program need not be framed exactly as the EPA program but must be at least as stringent as the EPA program to become authorized.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

The purpose of CERCLA is to "provide for liability compensation, cleanup, and emergency response for hazardous substances released into the environment and the cleanup of inactive hazardous waste disposal sites." The Act establishes the Hazardous Substances Response Trust Fund and the Post-Closure Liability Trust Fund.

Under the Response Fund of CERCLA, action may be taken that is necessary to abate any danger or threat from release of a hazardous substance causing imminent and substantial endangerment to the public health, welfare or the environment.

EPA's CERCLA policy is to first seek cleanup by responsible parties.

1. EPA will provide notice to potential responsible parties and an opportunity to confer with the Agency to develop a mutually satisfactory cleanup.
2. If these efforts are not successful, EPA will either use money from the Response Fund to finance the cleanup or use its enforcement authority to compel responsible parties to address the situation.
3. When the Response Fund is used, EPA will seek to recover the amount from responsible parties.

CERCLA specifies that responsible parties for a hazardous substance disposal or treatment facility from which there is a release or a threatened release requiring response action include:

1. The owner or operator, or any person who at the time of disposal was the owner or operator (TSDF);
2. Any person who accepted a hazardous substance for transport to the site (transporter); and
3. Any person who contracted for, agreed to, or otherwise arranged for transport, treatment or disposal of a hazardous substance at the site (generator).

A Post-Closure Fund is used specifically for response actions at hazardous waste disposal facilities which have complied with the applicable RCRA regulations and have been closed in accordance with their EPA permits. All

liability is transferred to the Post-Closure Fund 90 days after the owner or operator of the facility notifies the EPA Administrator that the facility has been properly closed and monitored for a period not exceeding five years.

Since CERCLA will not provide sufficient funding to remedy all situations, a systematic method is used to clean up priority sites which pose the greatest risk.

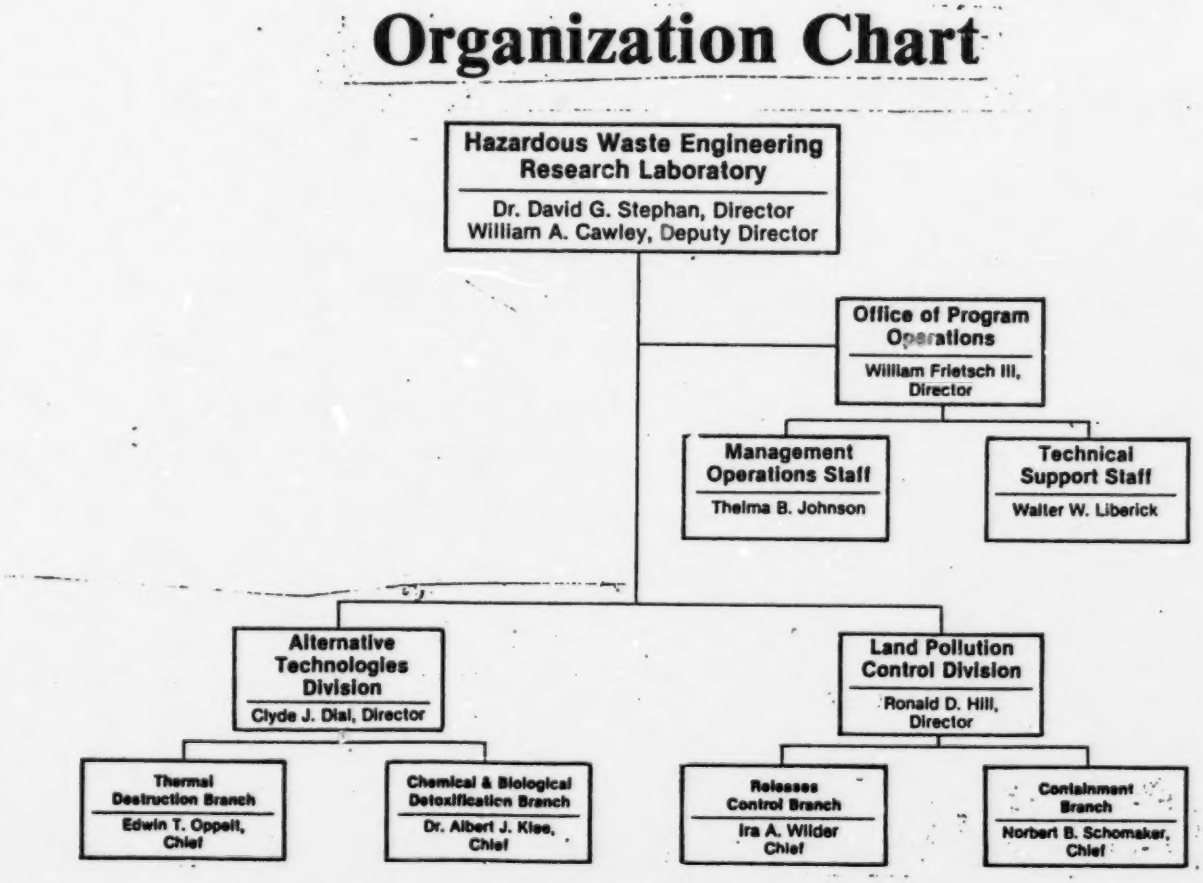
New EPA Approaches to Hazardous Waste Management Research

Since its inception in 1970, EPA has striven to determine which of the materials turned loose by mankind are harmful and, if so, to what degree. These findings have developed into a large mass of danger signs pointing to the direct and indirect harms we are doing to ourselves and to our environment. Much effort has gone into informing the public and restraining polluters from further damaging ourselves and our natural surroundings. While this has been, and continues to be, the prime thrust of EPA's activities, it has become strongly evident that work must be done to determine viable methods for controlling the hazardous waste already released as well as waste produced by continued industrial progress.

Hazardous Waste Engineering Research Laboratory, Cincinnati, Ohio, U.S.A.

The mission of the Hazardous Waste Engineering Research Laboratory is to provide an authoritative, defensible engineering basis in support of the policies, programs and regulations of EPA with respect to solid and hazardous wastes. The Laboratory defines and characterizes sources of pollution and catalyzes advances in the state-of-the-art of pollution control. It provides concepts for cost-effective solutions to difficult pollution problems and provides early warning of emerging sources of pollution.

An organization chart of the Laboratory is shown in Figure 8. There are two operating Divisions in the Laboratory--the Land Pollution Control Division and the Alternative Technologies Division.



U. S. Environmental Protection Agency
26 West St. Clair Street
Cincinnati, Ohio 45268
United States of America

Figure 8

The Land Pollution Control Division is responsible for research, development and demonstration of new and improved methods for the disposal of solid and hazardous wastes to the land and for the prevention, identification, control, and abatement of multi-media pollutants from uncontrolled hazardous waste sites and from releases of oils and hazardous materials. Director Ronald D. Hill is with us to participate in this conference.

This Division provides data necessary for the establishment of disposal guidelines which contribute to a better understanding and implementation of improved management practices. The program includes evaluation of new or improved equipment and systems for the containment, cleanup, removal, and ultimate destruction of oil and hazardous substances released to the environment from spills and from uncontrolled hazardous waste sites.

Close association is maintained with municipal, county, intergovernmental, and industrial organizations engaged in land disposal of toxic and hazardous waste.

The Land Pollution Control Division is comprised of two Branches--the Containment Branch and the Releases Control Branch. The Containment Branch is represented at this Joint Seminar by its Chief, Norbert B. Schomaker.

A listing of the Land Pollution Control Division's research areas and those individuals responsible for the programs is contained in Appendix A.

The Alternative Technologies Division, which I direct, is responsible for research to develop and assess technologies which are alternatives to conventional land disposal for hazardous waste.

The scope of the Division's program covers thermal destruction processes such as incinerators and high temperature industrial processes which employ hazardous waste as a fuel, and research into innovative physical, chemical, biological, and thermal destruction technologies. Research is also conducted

to assess the magnitude of air emissions from treatment facilities and determine methods for their control.

The evaluation of conventional treatment systems as alternatives to land disposal is another feature of the Division's work.

The Alternative Technologies Division has two Branches. E. Timothy Oppelt is Chief of the Thermal Destruction Branch, and Dr. Albert J. Klee is Chief of the Chemical and Biological Detoxification Branch. Both are representing their special areas here in Madrid.

A listing of the Alternative Technologies Division's research areas and those individuals responsible for the programs is contained in Appendix B.

REFERENCES

1. Westat, Inc., National Survey of Hazardous Waste Generators and Treatment, Storage and Disposal Facilities Regulated under RCRA in 1981, U.S. Environmental Protection Agency, 1984.

2. J. T. Baker Chemical Company, The Management of Hazardous Chemical Wastes--1983.

APPENDIX A

TECHNICAL ASSISTANCE REFERENCE DIRECTORY

LAND POLLUTION CONTROL DIVISION

Research Program . . . . . Ronald D. Hill/Norbert B. Schomaker/Ira Wilder

Technical Assistance Coordination. . . . . Eugene F. Harris

Superfund Technical Information Center . . . . . Hugh Masters

A. Containment Technology . . . . . Donald Sanning
   1. Barriers (slurry walls) . . . . . Dr. Walter Grube/Stephen James
   2. Covers . . . . . Janet Houthoofd/Robert Hartley
   3. Plume Management . . . . . Naomi Barkley/Douglas Ammon
   4. Bottom Sealing . . . . . Dr. Walter Grube
   5. Waste Storage . . . . . Janet Houthoofd/Carlton Wiles
   6. Mine Storage . . . . . Janet Houthoofd/Carlton Wiles
   7. Encapsulation/Overpacking . . . . . Carlton Wiles
   8. Stabilization/Fixation. . . . . Carlton Wiles/Janet Houthoofd
   9. Leachate Control & Treatment . . . . . Stephen James/Edward Opatken
   10. Permeable Treatment Walls . . . . . Jonathan Herrmann
   11. Fugitive Dust Control . . . . . Stephen James
   12. Freezing Technology . . . . . Janet Houthoofd
   13. Impoundments/ Waste Lagoons . . . . . Anthony Tafuri/Carlton Wiles
   14. Floating Spills . . . . . John Farlow

B. In-Situ Treatment . . . . . Ronald D. Hill/Donald Sanning/John Farlow
   1. Flushing . . . . . Richard Traver
   2. Freezing . . . . . Janet Houthoofd
   3. Electrokinetic . . . . . Jonathan Herrmann
   4. Vegetative . . . . . Dr. P.R. Sferra/Naomi Barkley/Dr. Walter Grube
   5. Grouting . . . . . Herbert Pahren
   6. Thermoplastics . . . . . Edward Opatken
   7. Precipitation . . . . . Anthony Tafuri/John Farlow/Edward Opatken
   8. Thermal Fusion (vitrification) . . . . . Donald Sanning
   9. Sorption . . . . . Michael Royer/Dr.John Brugger/Dr.Mike Roulier
   10. Ion Exchange . . . . . Anthony Tafuri/Richard Traver/Edward Opatken
   11. Chemical . . . . . Anthony Tafuri
   12. Biodegradation . . . . . Dr.Ronald Lewis/Dr.John Brugger
   13. Photochemical . . . . . Charles Rogers
   14. Delivery and Recovery Methods . . . . . Richard Traver

C. On-Site Technology . . . . . Frank Freestone
   1. Incineration Technology . Frank Freestone/Dr.John Brugger/James Yezzi
   2. EPA Developed On-Site Treatment/Control Technologies (Mobile Soil Washer, Mobile Carbon Regenerator, etc.) . . . Dr.John Brugger/Richard Traver
   3. Commercially Developed On-Site Treatment Technologies . . . . . Mary Stinson/Frank Freestone
   4. Mobile In-Situ Containment/ Treatment System . . . . . Richard Traver

D. Personnel Protection . . . . . Michael Royer/Michael Grueneld
   1. Protective Clothing and Equipment . . . . . Michale Royer
   2. Underwater Protective Clothing . . . . . Richard Traver
   3. Decontamination/Contamination Avoidance Procedures. . . . . Michael Royer/Mary Stinson
   4. Personal Hazard Detectors . . . . . Michael Royer

E. RCRA Facilities . . . . . Norbert B. Schomaker
   1. Landfill Design and Operation . . . . . Robert Landreth
   2. Waste Leaching . . . . . Dr. Mike Roulier
   3. Pollutant Migration . . . . . Dr. Mike Roulier
   4. Pollutant Control . . . . . Robert Landreth
   5. Flexible Membrane Liners . . . . . Robert Landreth
   6. Soil Liners . . . . . Dr. Walter Grube
   7. Surface Impoundments . . . . . Carlton Wiles
   8. Stabilization Processes . . . . . Carlton Wiles
   9. Volatile Emissions . . . . . Paul dePercin
   10. Muncipal Solid Waste . . . . . Robert Landreth/Norbert B. Schomaker
   11. Underground Mines . . . . . Carlton Wiles

F. Remedial Action Modeling . . . . . Douglas Ammon

G. Computer Activities . . . . . Douglas Ammon/Richard Griffiths

H. Remedial Action Costs . . . . . Dr. Hayes Goddard/Douglas Ammon

I. Building & Equipment Decontamination . . . . . Naomi Barkley

J. Compatibility Testing . . . . . Robert Landreth/Dr. Walter Grube
   1. Clay Liners and Slurry Backfills . . Dr.Walter Grube/Dr.Mike Roulier
   2. Flexile Membrane Liners . . . . . Mary Ann Curran
   3. Grouts . . . . . Herbert Pahren

K. Air Monitoring/Modeling . . . . . Paul dePercin/Stephen James

L. Dioxin . . . . . Donald Sanning
   1. Stabilization . . . . . Edward Opatken
   2. Dioxin Sorption/Desorption . . . . . Dr. Mike Roulier

M. Hydraulic Conductivity . . . . . Dr. Walter Grubr

N. Surface Impoundment Closure . . . . . Carlton Wiles

O. Mining Sites . . . . . Ronald D. Hill/Eugene F. Harris

P. Town Gas Works Sites . . . . . Edward Opatken

Q. Remedial Investigation/Feasibility Study Process . . . . . Douglas Ammon

R. Bench and Pilot-Scale Studies . . . . . Stephen James/Janet Houthoofd/Edward Opatken

S. Contaminated Land . . . . . Donald Sanning/Stephen James/Mike Gruenfeld

T. Leaking Underground Storage Tank Research . . . . . Richard Field/John Farlow/Anthony Tafuri

U. Remedial Action for Underground Storage Tank . . . . . Donald Sanning

V. Analytical Chemistry . . . Michale Gruenfield/Uwe Frank/Dr.S. Krishnamurthy

W. Mobile Analytical Laboratories . . . . . Michael Gruenfeld/Uwe Frank

X. Quality Assurance/Quality Control . . . . . Uwe Frank/Michael Gruenfeld

Y. Environmental Emergency Response Unit . . . . . Ira Wilder/James Yezzi

Z. Toxic and Flammable Gases . . . . . Stephen James

AA. Oil & Hazardous Materials Simulated Environmental Test Tank . . . . . Richard Griffiths/John Farlow

BB. Canine Olfaction . . . . . Hugh Masters/Ira Wilder

APPENDIX B

TECHNICAL ASSISTANCE REFERENCE DIRECTORY

ALTERNATIVE TECHNOLOGIES DIVISION

Programs and Facilities . . . . . Clyde J. Dial, Director

Thermal Destruction Branch . . . . . E. Timothy Oppelt, Chief

Chemical and Biological Detoxification Branch . . . Dr. Albert J. Klee, Chief

A. Thermal Destruction of Hazardous Materials
   1. Conventional and "At Sea" Incineration . . . . . Donald A. Oberacker
   2. Disposal of Hazardous Waste in Kilns . . . . . Robert E. Mournighan
   3. Non-Flame Thermal Destruction . . . . . Myron Malanchuk
      Robert E. Mournighan/Richard A. Carnes
   4. Disposal of Hazardous Wastes in Boilers . . . . . Donald A. Oberacker
      Ivars J. Licis/Robert E. Mournighan
   5. Innovative Technologies . . . . . Harry M. Freeman/C.C. Lee
   6. Engineering Analysis of Thermal
      Destruction Processes . . . . . C.C. Lee
   7. Microspray Burners . . . . . Louis H. Garcia
   8. Turbulennt Flame Reactor and Control
      Temperature Tower . . . . . Laurel J. Staley

B. Combustion Research Facility (Jefferson, AR) . . . . . Richard A. Carnes

C. Center Hill Facility (Cincinnati, OH) . . . . . George L. Huffman

D. Hazardous Waste Treatment
   1. Air Emissions from Treatment, Storage
      and Disposal Facilities . . . . . Benjamin L. Blaney
   2. Existing Treatment Technology for
      Hazardous Waste . . . . . Robert A. Olexsey/Harry M. Freeman
      Ronald J. Turner/Douglas W. Grosse/H. Paul Warner
   3. Physical/Chemical Separation
      of Hazardous Wastes . . . . . S. Garry Howell/Mark J. Stutsman
      John F. Martin/Donald L. Wilson
   4. Physical/Chemical Treatment of
      Soils and Sediments . . . . . Charles J. Rogers
      Dr.Alfred Kornel/Dr.John Glaser
   5. Biological Detoxification . . . . . Dr. P. R. Sferra
      Michael I. Black/Dr.John Glaser
   6. Emerging Technologies for Chemical
      Detoxification of Hazardous Waste . . . . . Charles J. Rogers
      Dr.Alfred Kornel/Donald L. Wilson
   7. Pesticide Disposal . . . . . Brian A. Westfall
   8. Metals Removal . . . . . S. Garry Howell
      T. David Ferguson/John F. Martin
   9. Hazardous Waste Minimization, Reuse . . . . . Harry M. Freeman

E. Oil Shale . . . . . Edward R. Bates